Incidental Findings on CT Angiography and How to Manage Them

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Because of recent technologic advances, coronary CT angiography (CTA) has become a potent imaging tool in the evaluation of patients with atypical chest pain (i.e., low to intermediate risk for both stable angina and acute coronary syndrome) [1]. Coronary CTA is expected to be increasingly used in clinical practice due to its high sensitivity and a negative predictive value that approaches 100% [2]. A major reason for performing coronary CTA is to evaluate coronary artery disease, and it is vital for interpreting physicians to focus on identifying abnormalities in the coronary arteries. However, neighboring organs such as central portions of the lungs, mediastinum, aorta, esophagus, upper abdominal organs, and thoracic skeleton are typically included in the examination, regardless of whether a restricted field of view (Fig. 50.1) or a full field of view is used for the evaluation of coronary arteries. Thus, it is critical that all interpreting physicians be careful not to overlook extracardiac incidental findings (Fig. 50.2). This chapter will discuss the most important incidental findings and an approach to their follow-up and management.

Use of a Small Versus Wide Field of View on Coronary CT Angiography

A discussion of the concept of the small and wide fields of view is a prerequisite to understand the ongoing debate regarding appropriate field of view in interpreting coronary CTA. The "small or restricted field of view" is a primary tool for analysis of coronary arteries using 16–25 cm^2 of coverage and thin collimation <1 mm. In contrast, "wide or full field of view" provides full coverage (35–40 cm^2) with thicker collimation of 2–5 mm encompassing the entire transverse extent of the chest. The latter is an additional reconstruction that may be obtained in order to provide and overread for extracardiac incidental findings [3, 4]. Because of the small size of the coronary arteries, reconstruction with a small field of view is required to maximize spatial resolution by reducing pixel size, facilitating precise analysis of the degree of stenosis and characterize plaque in these small structures. However, because all structures within a given CT slice have already been exposed to radiation, wide field of view images can be obtained without additional radiation dose.

The prevalence of incidental extracardiac findings (Tables 50.1 and 50.2) demonstrated on coronary CTA is fairly high ranging up to 67.0% on the wide field of view image with considerable variation in frequency due to study design and definition [3–17]. Of these, the prevalence of clinically important findings needing further work-up or management is less common and ranges from 1.2% to 22.7% [18]. It is certainly true that more malignant lesions (Fig. 50.3) will be found in wide field of view because a substantial number of lung cancers occur in the peripheral portion of the lungs, and most of breast tissue is excluded from a small field of view on coronary CTA. Earlier detection of lung or breast cancer may lead to curable surgical resection and favorable outcomes. In spite of this potential benefit, several reports [14, 19–22] have advocated exclusive use of small of view, although a larger group has favored the additional use of a wide field of view in interpreting coronary CTA [3, 4, 9, 11, 12, 15–18, 23–28]. There are differing opinions even within specialties [4, 14, 18–22, 27, 29]. The main reason for the controversy is the high prevalence of false-positive findings (i.e., low prevalence of malignancy less than 0.4%) on the larger field of view and lack of proven benefit of CT screening of lung cancer prior to the publication of the National Lung Screening Trial (NLST) [19, 20]. Work-up of numerous indeterminate lung nodules that ultimately prove to be benign may lead to extra cost, morbidity related to downstream testing and intervention, a low but potential risk of

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U. J. Schoepf (ed.), *CT of the Heart*, Contemporary Medical Imaging, https://doi.org/10.1007/978-1-60327-237-7_50

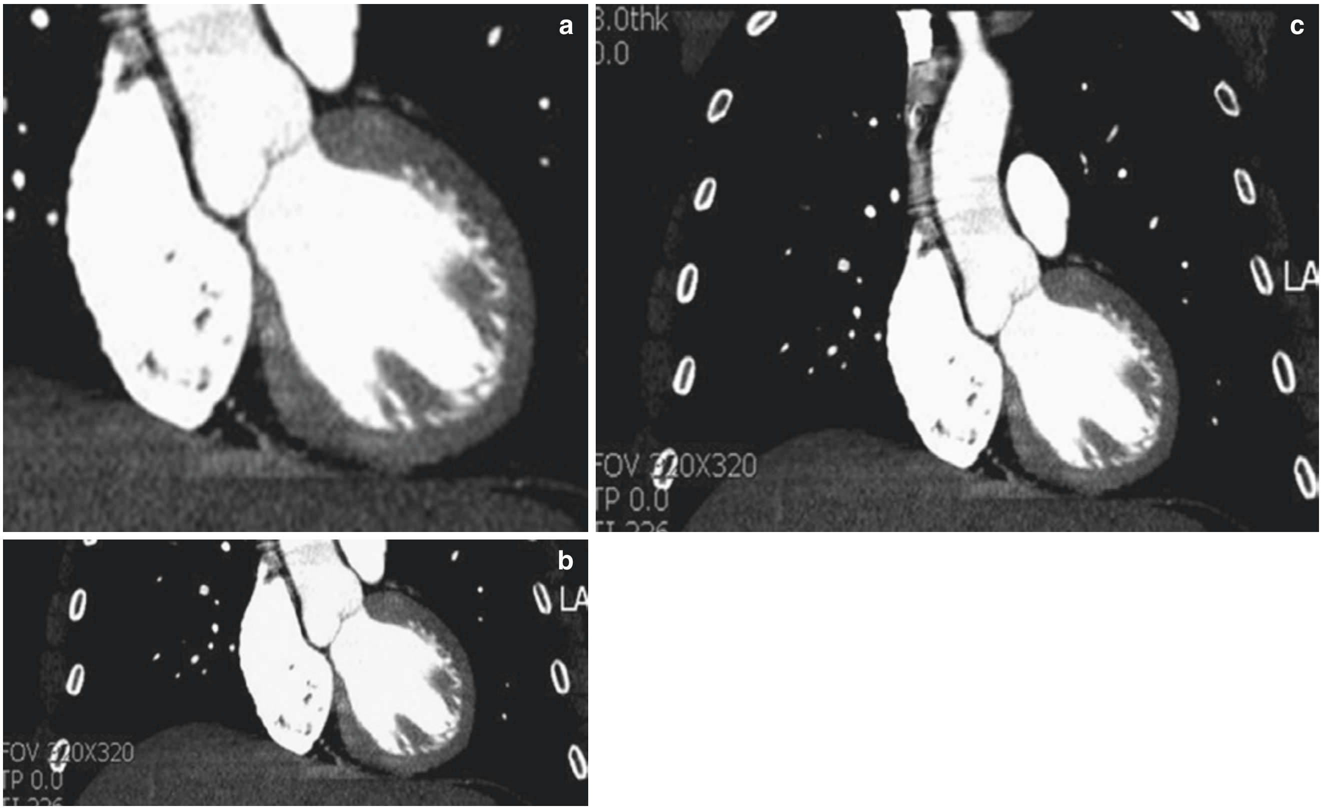

Fig. 50.1 Representative small (**a**) and wide (**b**) field of views on dedicated coronary CTA compared with the wide field of view (**c**) of triple rule-out protocol. The small field of view on dedicated coronary CTA includes the central lung parenchyma, aorta, mediastinum, bony structures, and abdominal organs. The wide field of view on dedicated coronary CTA includes about two-thirds of total lung volume

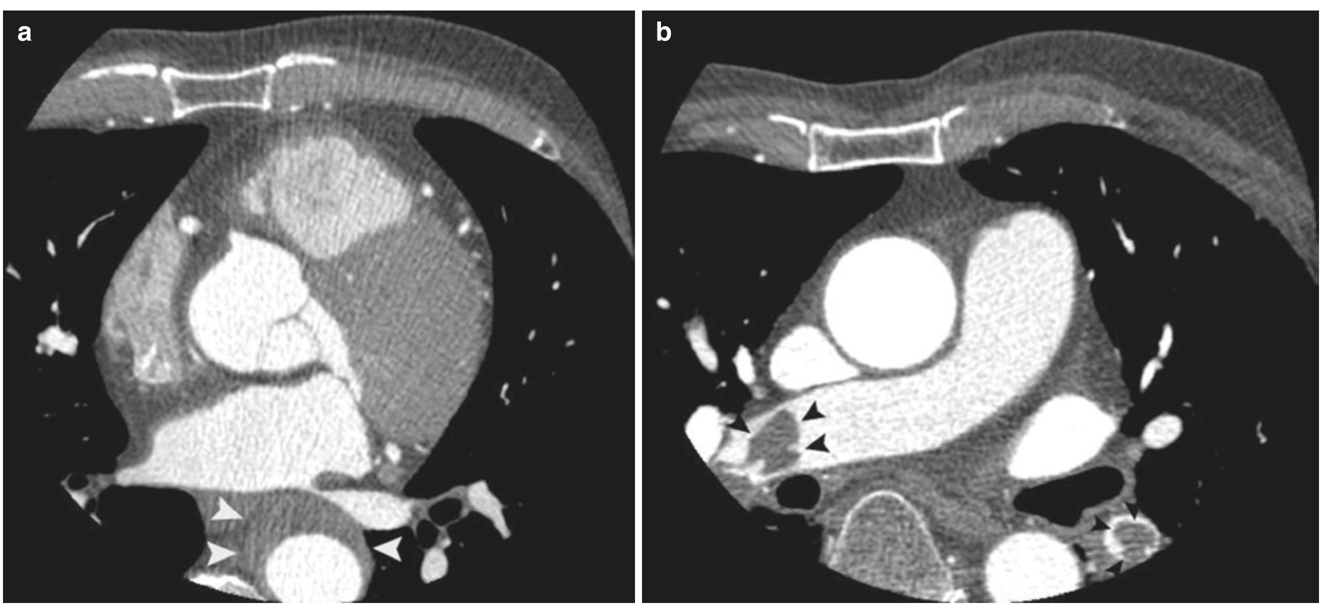

Fig. 50.2 Various important extracardiac findings demonstrated on small field of view coronary CTA image. Stanford type B intramural hematoma (arrowheads in **a**), central pulmonary emboli (arrowheads in **b**), esophageal wall thickening in a patient with gastroesophageal reflux disease (arrowheads in **c**), anterior mediastinal mass (arrowheads in **d**), and central lung cancer (arrows in **e**) are demonstrated even using a small coronary CTA field of view. Thus, all interpreters should be familiar with important extracardiac findings

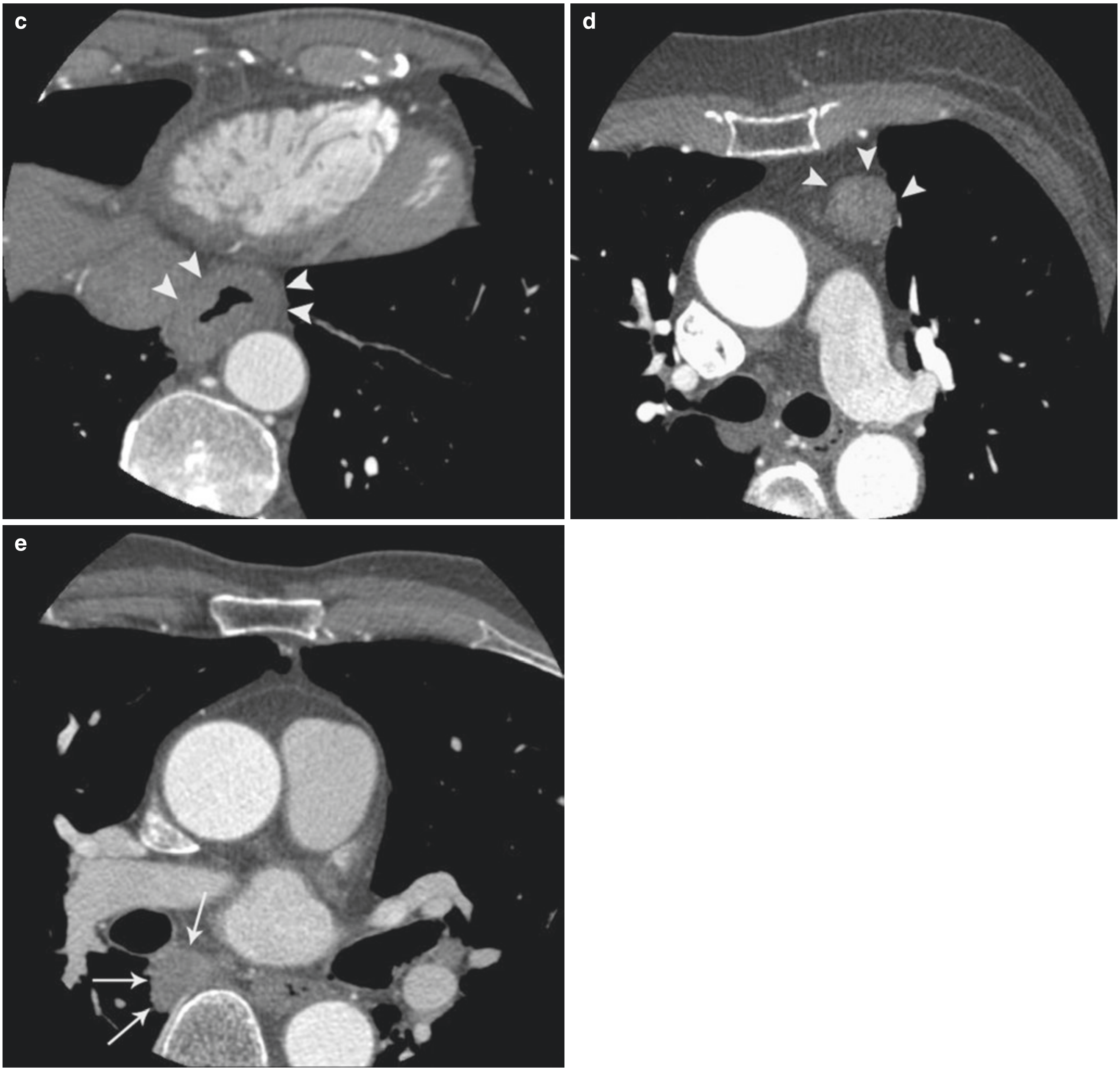

Fig. 50.2 (continued)

radiation-induced cancer, and anxiety on the part of both physicians and patients.

Results from the NLST indicated a lung cancer and overall mortality benefit for low-dose chest CT screening compared with screening with chest radiography. The randomized trial of more than 53,000 asymptomatic subjects who had a smoking history of more than 30 pack-years and were 55–74 years of age showed a 20.3% reduction of lung cancer mortality in the CT arm compared with chest radiography arm [30]. Based on the result of NLST, it seems reasonable to suggest that a wide field of view of coronary CTA be reconstructed and evaluated in the subset of patients who fit the entry criteria of the NLST.

However, even this suggestion should be viewed with caution because of differences in the patient selection. The individuals who enrolled in the NLST were entirely asymptomatic, whereas nearly all patients who undergo coronary CTA are referred for chest pain. Such a distinct referral pattern may affect the prevalence and characteristics of incidental extracardiac findings. In addition, the specifics of imaging protocols are different between low-dose chest CT and coronary CTA. The former is a nonenhanced CT with low radiation exposure, whereas the latter is obtained with intravenous contrast media and a higher radiation exposure due to ECG gating, potentially permitting lung nodules and certain other incidental findings to be more easily identified. For example, aortic dissection would be directly visible on coronary CTA but would be unlikely to be detected on a lung cancer screening study.

Table 50.1 Potentially clinically significant incidental extracardiac findings

Incidental finding	Prevalence (%)
Pulmonary nodule ≥4 mm	0.4–16.5%
Pulmonary consolidation	0.4–6.2%
Marked mediastinal lymphadenopathy	0.1–2.3%
Hiatal hernia	0.2–6.4%
Aortic dissection	0.0–0.3%
Aortic aneurysm	0.3–1.6%
Pulmonary embolism	0.0–1.9%
Breast nodule	0.0–0.6%
Fracture	0.0–0.3%
Metastatic bone destruction	Frequency not available
Pleural effusion	0.1–4.0%
Adrenal nodule	0.0–0.8%
Indeterminate hepatic nodule	0.0–2.3%
Cholelithiasis	0.1–3.6%

Moreover, there is inconsistency in the use of wide field of view in the radiologic practices depending on body part. Only small field of view images are typically reconstructed in other parts of body such as the orbits, inner ear, sinuses, and thoracic spine CT, even though radiation is received through the entire transverse CT section [29]. Lastly, it should be remembered that the typical *z*-axis coverage of dedicated coronary CTA does not include the upper one-third of the entire chest volume (i.e., tracheal carina to lung apices) [15]. This may lead to the false assumption that the entirety of both lungs is normal among patients undergoing a normal dedicated coronary CTA and their treating clinicians. Therefore, until a randomized trial is available to provide an overview about cost-effectiveness and outcome benefits, reconstruction of only a small field of view may be acceptable in patients undergoing dedicated coronary CTA, particularly in those of different age and smoking habits as compared with enrollees in NLST [29].

Table 50.2 Benign incidental extracardiac findings

Incidental finding	Prevalence (%)
Pulmonary nodule <4 mm	1.7–9.3%
Benign hepatic cyst	1.1–6.6%
Simple renal cyst	0.1–0.3%
Benign adrenal adenoma	0.1–0.6%

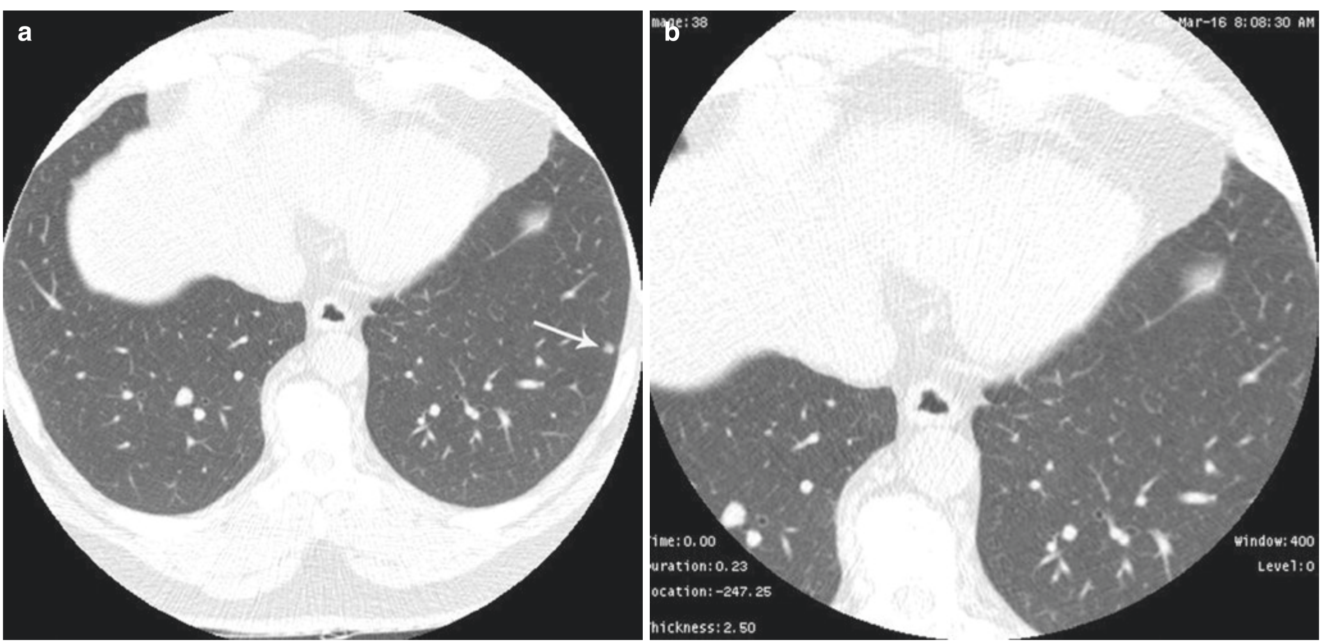

Fig. 50.3 Various important extracardiac findings identified only on a wide field of view coronary CTA image. (**a**, **b**) Solid pulmonary nodule 5 mm in diameter (arrow in **a**) is demonstrated in the left lower lobe on wide field of view image at the level of inferior cardiac margin in a 42-year-old male smoker. Note that the nodule is not visible on a small field of view image (**b**). (**c**) Enhancing 8 mm nodule (arrows in **c**) is demonstrated in the lateral portion of the left breast on a wide field of view coronary CTA image at the level of pulmonary artery bifurcation in a 42-year-old female patient. This nodule was not visible on a small field of view image. Breast ultrasonography was recommended in the patient for further evaluation. D. Right seventh rib destruction (arrowheads on **d**) is noted on a wide field of view bone setting image at the level of the right main pulmonary artery in an 81-year-old man. However, this lesion is not demonstrated on a small field of view image (**e**). The patient ultimately proved to have a rectal cancer

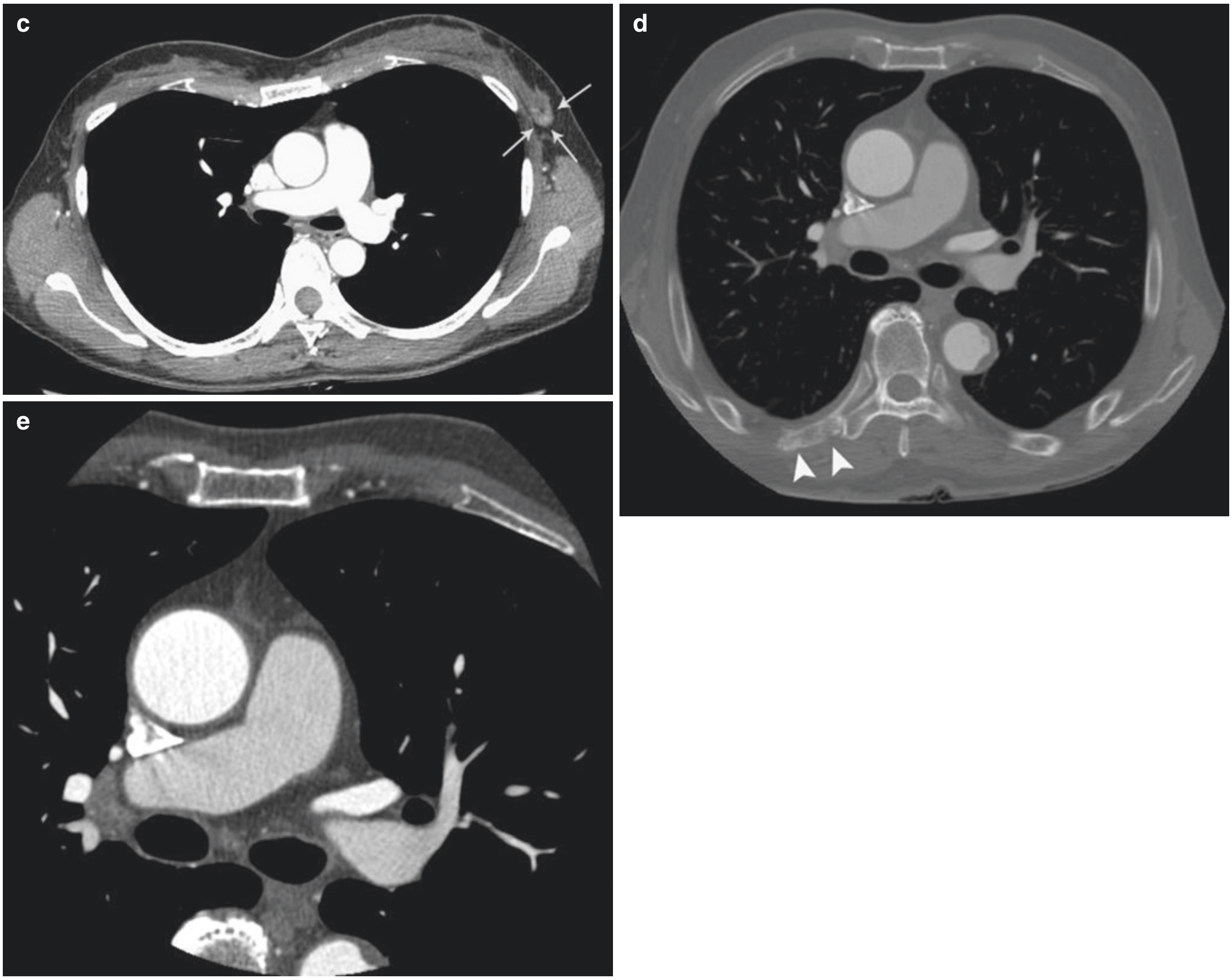

Fig. 50.3 (continued)

In the setting of acute chest pain, there is less debate than in stable angina regarding the use of a wide field of view (either dedicated coronary CTA or triple rule-out protocol) because an alternative cause of acute chest pain such as peripheral pulmonary embolism (Fig. 50.4), pneumonia, pneumothorax, rib fracture, cholecystitis, or pancreatitis can be identified when the coronary artery component is negative [13, 27]. According to one study, clinically important extracardiac findings that potentially changed patient management were identified up to 5% of patients presenting with acute chest pain. Thus, a stronger case can be made for a large field of view reconstruction in these patients [13, 31].

Practical Tips to Avoid Overlooking Important Incidental Findings

Because at least 8–22% (mean, 14%) of lung parenchyma, mediastinum, bone, chest wall, aorta, pulmonary arteries, and upper abdominal organs are included even in a small field of view [32], interpreters should be careful not to miss important extracardiac findings. Dedicated analysis of the coronary arteries with submillimeter collimation should be performed with a small field of view, and interpretation with three major image settings (mediastinal, lung, and bone window settings) should be routinely performed to analyze all organs visualized within the field of view beyond the coronary arteries, even if only a small field of view image is used [23, 33]. In contrast, if wide field of view images are available, the coronary arteries should be interpreted with small field of view image using submillimeter collimation, whereas extracardiac findings should be separately analyzed on wide field of view images with the three different window settings using 2–5 mm collimation. The typical Hounsfield unit (HU) levels and widths for mediastinal, lung, and bone window settings are 50 and 350, −500 and 1800, and 500 and 2000, respectively [33]. As a rule axial images are the best option to identify extracardiac findings. Although it is not routinely used in clinical practice, additional reconstruction of coronal or sagittal views may provide additional information to

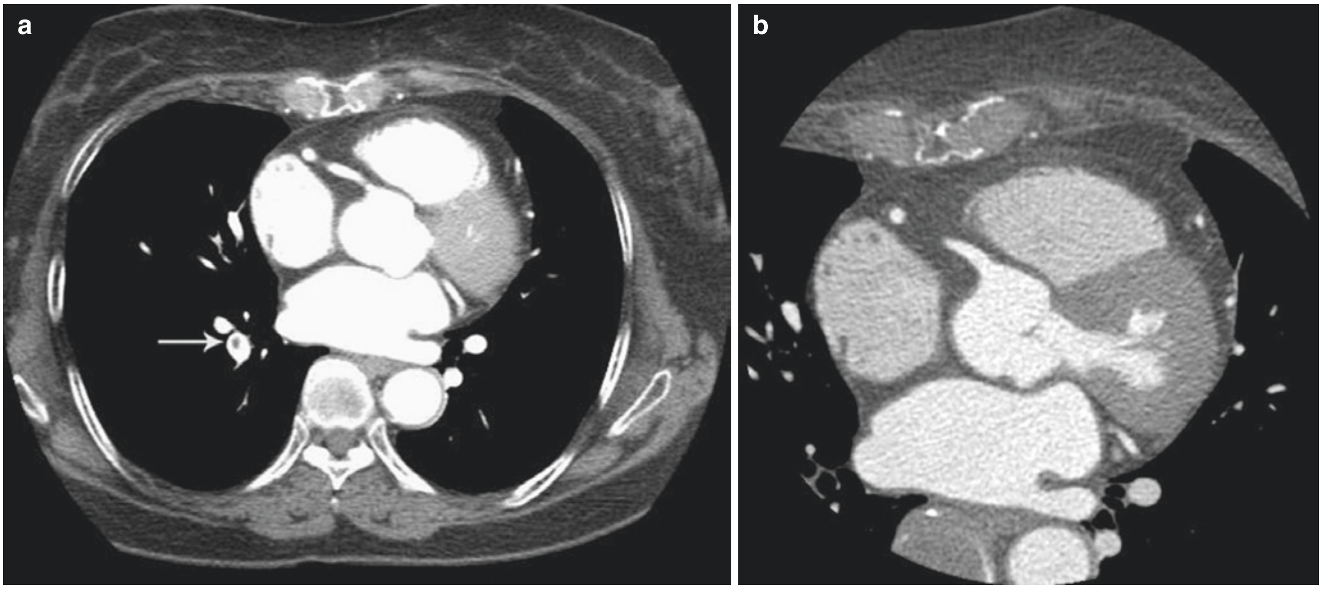

Fig. 50.4 Peripheral pulmonary embolism in a segmental pulmonary artery in the right lower lobe is identified only on a wide field of view image at the level of the left atrium in a 71-year-old woman. The patient presented with acute chest pain and the primary concern was acute coronary syndrome. Dedicated coronary CTA showed normal coronary arteries. Segmental pulmonary embolus is demonstrated on the wide field of view image (arrow on **a**), but not the small field of view image (**b**), thus showing the potential benefits of wide field of view imaging to provide an alternative cause of chest pain. Although most central pulmonary emboli are visible on a small field of view image, this may not be the case for more peripheral emboli

determine the precise location of a pulmonary nodule near a fissure or to identify vertebral pathology such as a compression fracture [33]. If an extracardiac finding is encountered, a multidisciplinary approach can be made used to select the next appropriate step. Importantly, those who interpret cardiac CTA should keep in mind that incidental extracardiac findings should always be compared on any previous studies to avoid unnecessary and potentially costly follow-up examinations.

Incidental Findings and How to Manage Them

Lung

An incidental pulmonary nodule is the most frequent finding in the evaluation of wide field of view on coronary CTA. The prevalence of all incidental pulmonary nodules and indeterminate pulmonary nodules needing further work-up is 0.9–36.2% and 0.4–16.5%, respectively [18]. A pulmonary nodule is defined as a relatively well-defined area of increased attenuation less than 3 cm in diameter. Certain characteristics can lead to a specific diagnosis. The presence of fat (HU of less than −10) in the pulmonary nodule on nonenhanced CT is diagnostic of benign hamartoma (Fig. 50.5). Central, diffuse, lamellated, or popcorn shape calcification in a smoothly marginated nodule is a typical CT finding of benign pulmonary nodule. In contrast, eccentric calcification in a pulmonary nodule does not necessarily indicate a benign etiology.

If an indeterminate nodule is found on coronary CTA, the nodule can be followed by the Fleischner Society recommendations. The recommendations classify lung nodules based on size and the presence or absence of risk factors such as smoking history or known primary cancer. Follow-up CT is not recommended in small (<4 mm) pulmonary nodules in a nonsmoker. In contrast, indeterminate pulmonary nodule more than 4 mm irrespective of risk factors should be followed by low-dose chest CT for up to 2 years to confirm resolution or stability. Stability over 2 years typically indicates that a solid pulmonary nodule is benign. However, an indeterminate pulmonary nodule with ground-glass attenuation should be followed more than 2 years because ground-glass or part-solid nodules that prove to be malignant typically have a longer doubling time [34].

Mediastinum

The most frequent significantly abnormal finding in the mediastinum is lymph node enlargement. Lymph node size less than 10 mm in short diameter is usually benign. If there is lymph node enlargement ≥10 mm in short diameter (Fig. 50.6) on coronary CTA, it should be further characterized by its shape and as well as any history of malignancy. The presence of a central fatty hilum or calcification in an enlarged lymph node or the concomitant presence of pneumonia may indicate

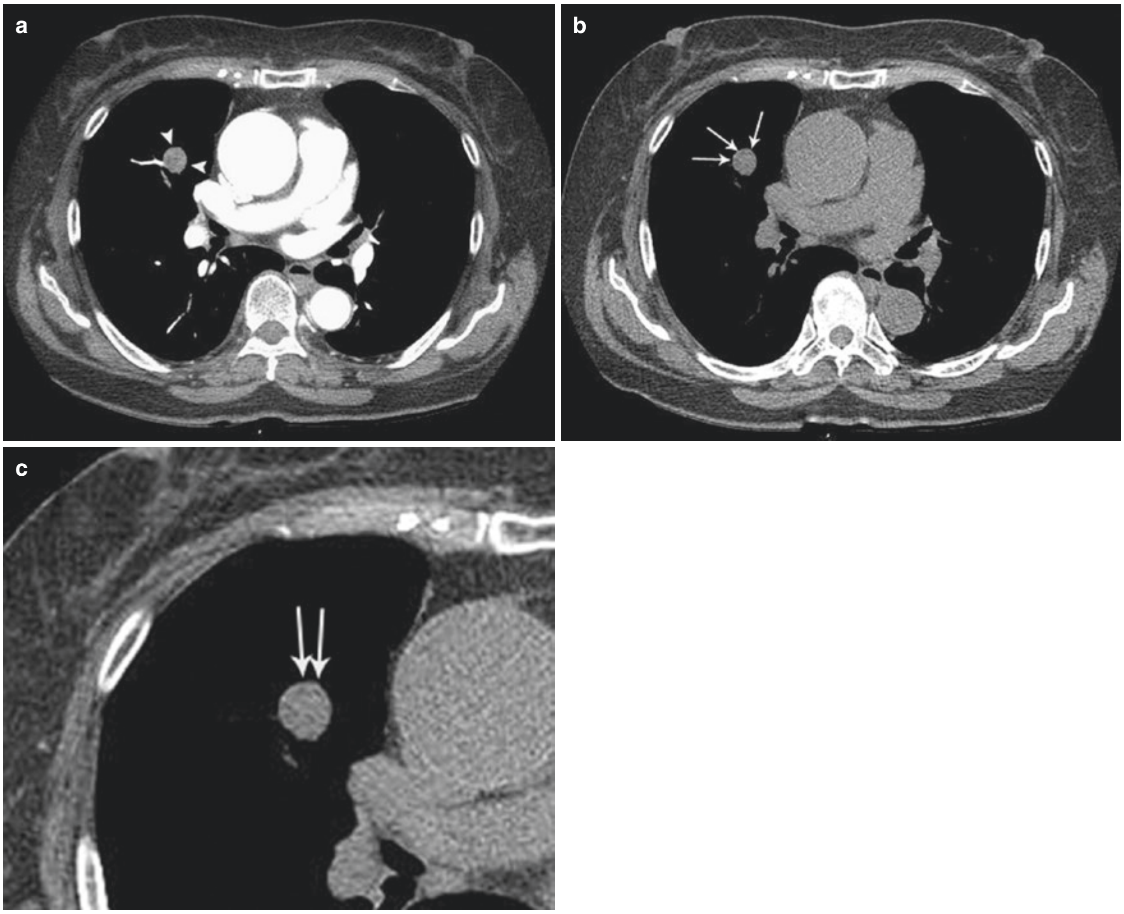

Fig. 50.5 Incidental pulmonary hamartoma in a 60-year-old female patient. Pulmonary nodule is demonstrated in the right middle lobe in enhanced (arrowheads in **a**), nonenhanced (arrows in **b**) wide field of view, and magnified (arrows in **c**) images at the level of the main pulmonary artery. Note fat attenuation (arrows in **c**) indicative of pulmonary hamartoma

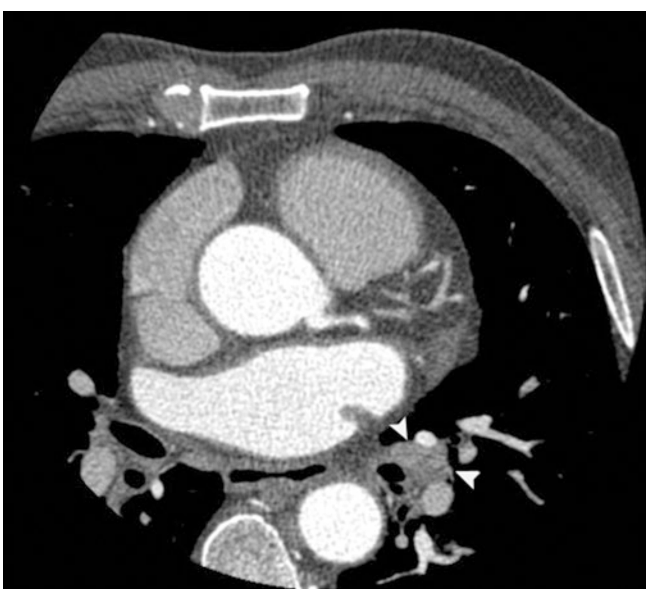

Fig. 50.6 Indeterminate left hilar lymph node enlargement on a small field of view image in a 66-year-old male. Left hilar lymph node enlargement (arrowheads) measuring about 12 mm in short diameter is demonstrated on a small field of view image of coronary CTA at the level of the left atrium. Follow-up chest CT was recommended

a benign etiology. In contrast, lymph node enlargement that lacks benign features should be followed by CT or further evaluated [23, 33]. Conglomerate lymph node enlargement with peripheral rim or diffuse enhancement can be a finding in tuberculous or malignant lymph node enlargement. Another frequent mediastinal finding is an esophageal abnormality such as hiatal hernia or esophageal wall thickening. The gastroesophageal junction is located above the diaphragmatic hiatus on CT in patients with a hiatal hernia. This finding may explain symptoms of chest pain due to gastroesophageal reflux disease. If gastroesophageal reflux disease is suspected, endoscopic evaluation can be performed.

Aorta

The clinical presentation of aortic dissection and acute coronary syndrome can be quite similar. Thus, the aorta should be evaluated carefully on coronary CTA even when using a small field of view. Aortic dilatation or aneurysm is a frequent incidental finding on coronary CTA. An aortic aneurysm (Fig. 50.7) is defined as aortic dilatation more than 150%

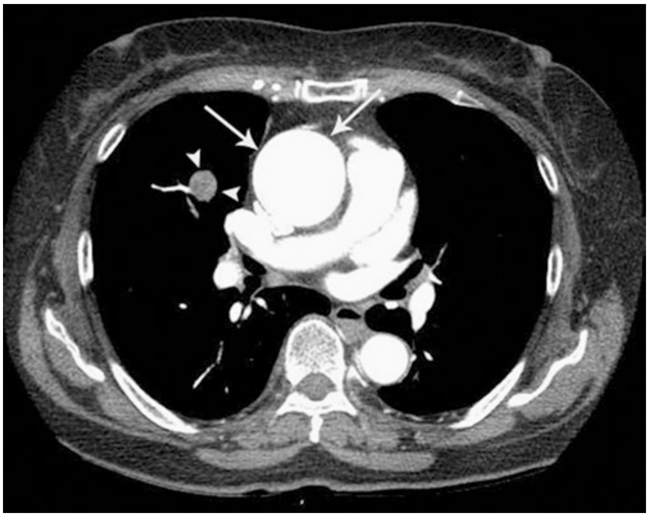

Fig. 50.7 Ascending aortic aneurysm on a small field of view image in a 60-year-old female patient. This is the same patient with Fig. 50.5 who has hamartoma (arrowheads) in the right middle lobe. Note ascending aortic aneurysm (arrows) measuring approximately 50 mm in diameter

(often 5 cm in diameter) compared with size of a normal aorta. Six months to 1 year CT follow-up is recommended to evaluate changes in the aortic diameter. If there is greater than 1 cm aortic dilatation over the course of a year, surgical intervention should be considered.

Pulmonary Artery

Most central pulmonary emboli may be visible even in a small field of view image on coronary CTA. However, it should be stressed that dedicated coronary CTA targets the left circulation but not the right. Thus, the visibility of central pulmonary emboli depends on the degree of enhancement in the pulmonary arteries. In contrast, peripheral pulmonary embolism in segmental or subsegmental pulmonary arteries may only be noted on a wide field of view. In patients with pulmonary embolism demonstrated on CTA, lower extremity Doppler ultrasonography can be recommended to evaluate for deep vein thrombosis.

Breast

The prevalence of breast nodules found on coronary CTA is up to 0.6% [3, 4, 14, 26, 32]. If a breast nodule (Fig. 50.3c) is identified on a wide field of view coronary CTA image, ultrasonography and mammography should be performed to exclude early breast cancer.

Thoracic Skeleton and Pleura

It is important to identify the presence of acute rib fractures because they may be an alternative cause of chest pain [33]. It is of value to remember that rib fractures can occur without a history of blunt trauma, for example, due to chronic cough or stress-related injury. It is also important to identify any metastatic rib lesion (Fig. 50.3d) or vertebral destruction to avoid unnecessary additional examinations to confirm the diagnosis. Pleural effusion is another common incidental finding. Pleural effusion in the dependent portion of the chest with low density (<20 HU) and no enhancement usually indicates a transudate. Although the presence of pleural linear or nodular enhancement, loculation, or high attenuation of content (HU >20) may suggest exudative or complicated effusion, the absence of such findings does not completely exclude an exudative or malignant pleural effusion [33].

Upper Abdominal Organs

Frequent abdominal incidental findings are cysts (Fig. 50.8), hemangiomas, adrenal nodules (Fig. 50.9), and gallbladder or renal stones. Most hepatic nodules less than 10 mm in diameter are benign in asymptomatic patients. Standard recommendations such as the Fleischner guidelines for indeterminate lung nodule do not exist for follow-up of incidental hepatic nodules in low-risk patients [23]. Peripheral nodular enhancement on the arterial phase of CT is typical for a hemangioma. Occasionally, hepatocellular carcinoma or hypervascular metastasis such as melanoma may be a cause of hepatic nodule with high attenuation on coronary CTA. Thus, the possibility of malignant hepatic nodule should be considered in patients with CT features of liver cirrhosis or history or a primary focus of cancer. According to the recently published Liver Imaging-Reporting and Data System (LI-RADS), a nodule demonstrated on CT in patients at high risk for hepatocellular carcinoma (e.g., liver cirrhosis) should be considered at least as an indeterminate nodule (≥LR-3), irrespective of size. In this scenario, dynamic abdomen CT is recommended [35]. It should be kept in mind that coronary CTA is not the optimal examination to identify hepatic nodules because it is not obtained in a parenchymal venous phase.

An incidental adrenal nodule is another common abdominal finding within the field of view of coronary CTA. Hounsfield units less than 10 on nonenhanced CT images often indicate a benign adenoma because most adenomas contain a fatty component. However, adrenal adenomas with scanty fat often have a higher CT attenuation on nonenhanced CT. In such cases, a dedicated abdominal CT study showing a characteristic washout pattern is helpful to discriminate an adenoma from a malignant lesion. Greater than 40% washout on a 15 min delayed CT image indicates an adenoma [23].

Fig. 50.8 Hepatic cyst in a 50-year-old male patient. Hepatic cyst with typical low attenuation (i.e., HU near zero) (arrowheads) is noted on a wide field of view image at the level of dome of liver

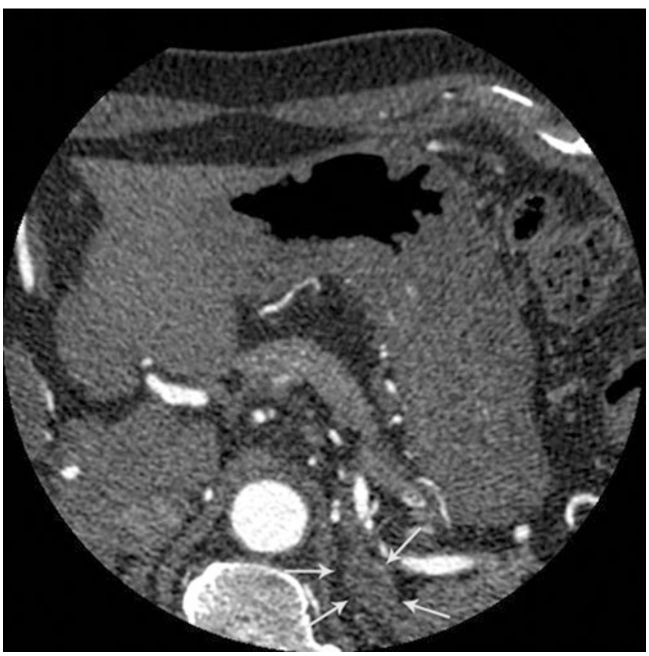

Fig. 50.9 Nonspecific left adrenal nodule in a 50-year-old male patient. Nonspecific left adrenal nodule (arrows) measuring approximately 10 mm is noted on a small field of view image at the level of adrenal gland. In this instance, the characteristic washout pattern is helpful to discriminate an adenoma from malignant lesion. Greater than 40% washout on a 15 min delayed CT image indicates an adenoma

Conclusion

Many important extracardiac findings are demonstrated even on the small field of view image of coronary CTA. Thus, interpreting physicians irrespective of specialty should be familiar with various important extracardiac findings. In the acute chest pain setting, additional reconstructions and analysis with a wide field of view may be valuable to identify an alternative cause of chest pain. For patients with stable angina, a small field of view image on coronary CTA may be acceptable to evaluate extracardiac findings.

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